UNIVERSITI PUTRA MALAYSIA

COMPARATIVE EFFICACY OF VARIOUS SOURCES AND RATES OF PHOSPHATE ROCKS TO OIL PALM SEEDLINGS

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By

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Dedicated to my parents

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LIST OF ABBREVIATIONS

2% CA	-	2% Citric Acid
2% FA	-	2% Formic Acid
NAC	-	Neutral Ammonium Citrate
TSP	-	Triple Sperphosphate
CIRP	-	Christmas Island Phosphate Rock
NCPR	-	North Carolina Phosphate Rock
JPR	-	Jordanian Phosphate Rock
APR	-	Algerian Phosphate Rock
CPR	-	China Phosphate Rock
TPR	-	Tunisia Phosphate Rock
OPRS	-	Oil Palm Research Station
Cf	-	Capacity Factor
Cp	-	Water Soluble P (Intensity Factor)
DMRT	-	Duncan's Multiple Range Test
E (t)	-	Isotopically Exchangeable Phosphorus at Time t
E1	-	Isotopically Exchangeable Phosphorus at 1 Minute
LSC	-	Liquid Scintillation Counter
n	-	Power Function Describing E(t)

Pdff	-	Phosphorus Derived from Fertilizer
PR	-	Phosphate Rock
PRs	-	Phosphate Rocks
r/R	-	Radioactivity in the Solution after Specific Time
R	-	Initial Radioactivity
RAE	-	Relative Agronomic Effectiveness
SA	-	Specific Activity
AAS	-	Atomic Absorption Spectrophotometer

Abstract of the Thesis submitted to the Senate of Universiti Putra Malaysia in Fulfillment of the Requirements for the Degree of Master of Agricultural Science.

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MUHAMMAD EDWIN SYAHPUTRA LUBIS

June 1997

Chairman : Associate Prof. Dr. Zaharah A. Rahman

Faculty : Agriculture

Phosphate Rocks (PR) from various geographical locations are being imported into the Malaysian market mainly from Algeria, North Carolina (USA), Tunisia, China etc. PR vary widely in their physical, chemical and mineralogical properties. Consequently, the solubility and agronomic effectiveness of PR sources also vary widely. In addition, the agronomic effectiveness of PR depends on interactions between several factors, particularly PR material characteristics, soil properties, crop characteristics, and

environmental conditions. Hence, There is a need to evaluate the efficacy of various sources of PR as phosphate source for plant growth. In view of this, a glasshouse experiment using oil palm seedlings and a laboratory incubation experiment were used to evaluate the efficacies of these sources of PR. The study was undertaken with the following objectives :

1. to assess the solubility of PR in soil by various solubility tests.
2. to evaluate the dissolution of PR sources in an acid Malaysian soil, using an incubation experiment.
3. to determine the relative agronomic effectiveness of PRs to oil palm seedlings in glasshouse experiment.
4. to characterize the immediate and residual availability of PR using the E-value approach.

The solubility test showed that the neutral ammonium citrate (NAC) method gave more consistent results and was highly correlated with P uptake compared to 2 % formic acid and 2 % citric acid solubility tests. The solubility value as expressed by % of rock, gave higher coefficient correlation than the solubility value as expressed by % of total P_2O_5. Based on neutral ammonium citrate solubility test, the rankings were : TSP > NCPR > APR > TPR > JPR >

CIPR > CPR. The correlation coeficient between solubility test and plant P uptake was almost constant with increasing rate of P applied.

Based on the glasshouse study using oil palm seedlings , TSP prove to be superior in promoting P uptake. The relative agronomic effectiveness (RAE) data for dry weight gave a similar trend to that for P uptake. In general amongst the PRs tested, the ranking of RAE can be classified separated into three categories, i.e : high (NCPR and APR), medium (TPR and JPR) and low reactivity (CIPR and CPR),.

The incubation study showed that the addition of PRs can improve some soil chemical characteristics. In this study it was observed that PRs improved soil pH, Exchangeable Ca and extractable P. The extent of PR dissolution increased with increasing incubation period. The percent dissolution of PR was much higher at lower level of PR application.

The E-value determinations showed that the ability of PR in providing available P in the soil depend on their reactivity. On the whole the ranking of reactivity from this study is in order of : NCPR>TPR>APR>JPR>CPR>CIPR. A good correlation was also observed between P uptake and E-values at 1 minute, and P in concentration in soil-water suspension (Cp)

Furthermore, it was observed that the highly reactive PR (NCPR, APR and TPR) were always ranked higher than the ones with low reactivity (CIPR and CPR) for all methods tested. The E-value method is a better method since the isotopic exchange technique provides the most complete analysis of soil available phosphate. It can asses the immediate and residual availability of P, determine the relative agronomic efficiency (RAE) of P fertilizers and calculate the P derived from fertilizer (%Pdff). The E-value method is a good method to estimate soil P fixing capacity without the need for conducting field or glasshouse experiments. It also has an advantage over chemical extractants because it does not disturb the soil components.

Abstrak Tesis yang Dikemukakan Kepada Senat Universiti Putra Malaysia Sebagai Memenuhi Syarat Keperluan Untuk Ijazah Master.

PERBANDINGAN KECEKAPAN AGRONOMIK PELBAGAI JENIS BATUAN FOSFAT DAN KADAR PEMBERIANNYA PADA ANAK POKOK KELAPA SAWIT

Oleh

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Dewasa ini, Malaysia mengimport pelbagai jenis batuan fosfat yang didapati dari pelbagai lokasi seperti batuan fosfat dari Tunisia, Algeria, North Carolina, China dan lain-lain. Setiap jenis batuan fosfat mempunyai ciri-ciri fizikal, kimia dan mineralogi yang berbeza diantara satu sama lain. Ini menyebabkan kelarutan dan keberkesanan agronomik sesuatu batuan fosfat berbeza-beza. Kecekapan agronomik batuan fosfat adalah bergantung kepada beberapa faktor seperti ciri-ciri batuan fosfat itu sendiri, sifat-sifat tanah, jenis

tanaman dan keadaan persekitaran. Untuk tujuan ini, kajian di makmal dan kajian di rumah kaca yang menggunakan anak benih kelapa sawit telah dijalankan untuk menilai kecekapan agronomik beberapa jenis batuan fosfat. Selaras dengan itu tujuan kajian ini dijalankan adalah :

1. Untuk menilai kelarutan pelbagai batuan fosfat di dalam tanah dengan menggunakan beberapa ujian kelarutan tak langsung.

2. Untuk menilai kelarutan pelbagai batuan fosfat di dalam tanah berasid berdasarkan kajian inkubasi.

3. Untuk mengetahui kecekapan agronomik pelbagai batuan fosfat berdasarkan kajian di rumah kaca dengan menggunakan anak benih kelapa sawit.

4. Untuk mencirikan kebolehdapatan segera dan sisa baki P di dalam tanah dengan melibatkan percubaan kinetik penukaran isotopik.

Ujian kelarutan tak langsung yang telah dijalankan menunjukkan larutan ammonium sitrat neutral memberikan nilai korelasi yang positif dan tinggi dengan pengambilan P oleh anak pokok kelapa sawit jika dibandingkan dengan ujian 2% asid formik dan 2% asid sitrik. Nilai kelarutan yang dikira berdasarkan peratusan batuan memberikan korelasi koefisien yang lebih baik jika dibandingkan dengan nilai kelarutan yang dikira berdasarkan peratusan jumlah P_2O_5. Berdasarkan kelarutan di dalam larutan ammonium sitrat neutral, keputusan yang didapati adalah :

TSP > BFNC > BFA > BFT > BFJ > BFPK > BFC.

Koefisien korelasi diantara ujian kelarutan tak langsung dengan pengambilan P oleh anak pokok kelapa sawit adalah menunjukkan kostant dengan pertambahan kadar pemberian P di dalam tanah.

Berdasarkan kajian yang dijalankan di rumah kaca, pengambilan P yang paling tinggi adalah pada rawatan TSP. Kecekapan agronomik berdasarkan berat kering memberikan keputusan yang sama dengan kecekapan agronomik berdasarkan pengambilan P oleh tanaman. Pada amnya kecekapan agronomik boleh dibahagikan kepada tiga kategori iaitu : tinggi (BFNC dan BFA), sederhana (BFT dan BFJ) dan rendah (BFPK dan BFC),

Kajian inkubasi menunjukkan pemberian fosfat boleh meningkatkan beberapa ciri tanah. Pemberian batuan fosfat dapat meningkatkan pH tanah, tukarganti Ca dan P terekstrak. Kadar kelarutan batuan fosfat meningkat dengan pertambahan masa inkubasi dan peratusan pelarutan batuan fosfat adalah lebih tinggi pada paras pemberian batuan fosfat yang rendah.

Kaedah kinetik penukaran isotop yang dilakukan di dalam makmal mendapati bahawa keupayaan batuan fosfat untuk membekalkan P tersedia di dalam tanah adalah bergantung kepada kereaktifan batuan tersebut. Keputusan kajian ini, menunujukkan susunan kereaktifan adalah seperti : BFNC, BFT, BFA, BFJ, BFC dan BFPK. Kajian ini juga memberikan nilai korelasi yang positif dan tinggi dengan pengambilan P oleh anak pokok kelapa sawit.

Keputusan keseluruhan kajian menunjukkan BFNC, BFA, BFT, BFJ mempunyai kereaktifan yang paling tinggi dibandingkan dengan BFC dan BFPK dengan menggunakan apa ujian sekalipun. Secara am, kesemua kaedah yang digunakan memberikan keputusan yang sama. Oleh itu kaedah isotop adalah kaedah yang lebih baik, karena kaedah ini boleh memberikan kebolehdapatan segera dan sisa baki P di dalam tanah, menentukan kecekapan agronomik, penentuan P yang didapati dari baja dan kaedah ini juga boleh menentukan keupayaan pengikatan P oleh tanah tanpa perlu menjalankan kajian di rumah kaca atau di ladang. Kaedah ini juga lebih baik jika dibandingkan dengan menggunakan larutan pengektrak karena kaedah ini tidak mengganggu komponen tanah.

CHAPTER 1

INTRODUCTION

Phosphorus deficiency can be a major factor in declining crop production in many acidic agriculture soils in developing countries (Chien, 1995; Chien and Menon, 1995). In acid soils of the tropics, including Malaysia, P availability is one of the major limiting factors in crop production, because most of the soils are inherently low in P due to the presence of oxides and hydroxides of Fe and Al that fix large amounts of applied P fertilizer (Owen, 1953; Puspharajah et al., 1977; Kalpage and Wong, 1978; Zaharah, 1979). Therefore, application of phosphate fertilizers is required for them to be highly productive.

It has been shown that direct application of phosphate rock (PR) may be an agronomically and economically attractive alternative to the use of the more expensive soluble P fertilizers (Khasawneh and Doll, 1978; Hammond et al., 1986; Chien et al., 1990; Chien and Friesen, 1992; Sale and Mokwunye, 1993).

Numerous studies have shown that direct application of PR is especially favourable for the plantation crops, e.g., oil palm, rubber, coconut and tea (Ling et al., 1990; Pushparajah et al., 1990).

Several studies have also shown that phosphorus is a major plant nutrient for proper growth and production in oil palm (Zakaria et al., 1990; Fong and Sofi, 1993; Fong, 1993) because many of the vital growth processes in oil palm are associated with the phosphorus element, for instance nucleic acids which govern the process of cell development as well as affect fruit ripening. In addition, an adequate presence of this element is necessary for the efficient use and action of nitrogen (Turner and Gillbanks, 1974 ; Adiwiganda and Siahaan, 1994). One of the cheapest source of P for oil palm is phosphate rock (PR). In acidic soils of the humic tropics, PR was found to be as efficient as the more soluble phosphate in term of yield response of oil palm (Chan, 1981). The residual effect of PR was found to be significant in acid soils for at least two to four years (Chan, 1981).

Malaysia has been using PR from Christmas Island (CIPR) since the 1930's, but recently, PR from various geographical locations are being imported into the Malaysian market. This includes PR from Jordan, North Carolina, Tunisia, China etc. PR vary widely in their physical, chemical and mineralogical properties (Lehr and McClellan, 1972; Chien, 1995). Consequently, the solubility and agronomic effectiveness of PR sources also vary widely (Chien, 1995 ; Sale and Mokwunye, 1993). In addition the agronomic effectiveness of phosphate rocks depend on interactions between several factors, particularly PR mineralogical properties, soil properties, crop characteristics, and environmental conditions (Khasawneh and Doll, 1978 ; Hammond et al., 1986).

Hence, there is a need to evaluate the efficacy of various sources of PR as a phosphate source for plant growth. The usual method of investigation involve field trials to evaluate biological responses to an application of various forms of P fertilizers. But field experiments are generally time consuming and expensive. In view of this, a glasshouse experiment using oil palm seedlings and a laboratory experiment will be used to evaluate the efficacy of various sources of phosphate rocks.

Thus, the study was undertaken with the following objectives :

- To Assess the solubility of PR in the soil by using various indirect solubility test.

- To assess the dissolution of PR sources in an acid Malaysian soil, using incubation experiment.

- To evaluate the efficacy of the various sources of phosphate rocks versus TSP to oil palm seedlings

- Quantification of P uptake from various phosphate rocks in oil palm seedlings

- Investigating the interaction between sources and rates of application of phosphate rocks to oil palm seedlings.

- To assess the immediate and residual availibility of P by the E value approach.